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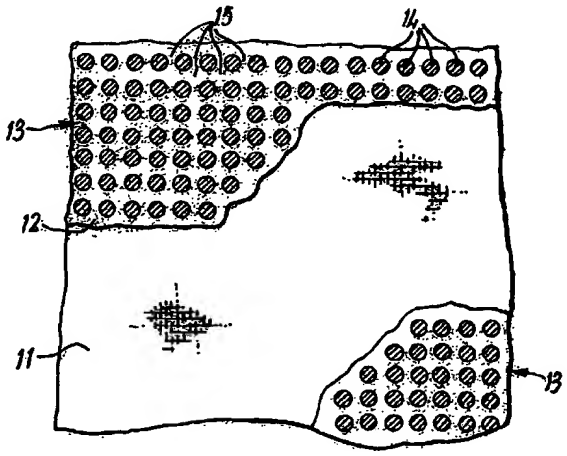
(54) Title: RETROFLECTIVE FABRICS AND METHOD OF PRODUCTION



(57) Abstract: A retroreflective fabric having a print or coating having retroreflective pattern areas of aligned, hemispherically coated retroreflective microbeads. In one implementation of the invention a breathable and/or moisture management fabric has adhered thereto one or more arrays of dots each comprising a plurality of aligned, hemispherically coated retroreflective microbeads in such a way that the fabric is exposed for breathability and/or moisture management at interstices between the dots. In an alternative implemenation, a breathable fabric has adhered thereto one or more arrays of dots each comprising an area of fabric surrounded by an area of aligned, hemispherically coated retroreflective microbeads adhered to the fabric in such a way that the fabric is exposed for breathability and/or moisture management in the dot areas.

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RETROREFLECTIVE FABRICS AND METHOD OF PRODUCTION

This invention relates to retroreflective fabrics and methods for making them.

Retroreflective fabrics are made by printing or coating on to a fabric a retroreflective ink or coating. In some such fabrics, the ink coating contains microbeads hemispherically coated with aluminium. During the printing or coating the microbeads are randomly aligned with only a proportion of them so disposed as to be capable of retroreflectivity.

The beads not so disposed are, in effect, wasted and also have a deleterious effect on the daylight appearance of the fabric, tending to give a grey cast to it.

Tapes, capable of a greater degree of retroreflectivity, are made by embedding microbeads in an adhesive layer on a backing and metallising the exposed hemispheres of the microbeads, then transferring the microbeads to an adhesive coated tape so that the metallised surfaces are embedded in the adhesive in the tape, the microbeads now being all aligned and all contributing substantially 100% to the retroreflectivity. Retroreflective tape, whilst being useful in many applications, is, however, of limited usefulness.

The present invention provides retroreflective fabrics and methods for making the same that have the degree of retroreflectivity of a tape, or at least much more nearly so than conventional ink-printed or coated fabrics, whilst being more generally useful.

The invention comprises a retroreflective fabric having a print or coating having retroreflective pattern areas of aligned, hemispherically coated retroreflective microbeads.

The fabric may be one which is breathable, the term "breathable" referring to the ability of the fabric to allow the passage of air or other gases or moisture to pass through the fabric.

Additionally or alternatively, the fabric may be one which has moisture management properties. For example, the fabric may be one which is intended to move moisture away from its internal surface (for instance, a surface which may contact the skin of the wearer) by a mechanism such as a wicking action. The fabric may also permit rapid or gradual migration of moisture to the outer surface of the fabric in a controlled manner where evaporation will occur. The result of such moisture management is to keep the internal surface of the fabric substantially dry.

The present invention allows fabrics to be produced with highly reflective areas without unacceptably compromising the breathability and/or moisture management properties of the fabric.

The beads may be adhered to the fabric through a transfer adhesive, especially one which is not water based.

The fabric is typically at least 1 metre wide, e.g. about 1.5 metres wide.

The print or coating may be applied in a dot pattern or a reverse dot pattern. By a "dot pattern" is meant that the print or coating is applied in a pattern of dots, eg. circular, square, rectangular, triangular or other shaped dots separated by blank areas, while by a "reverse dot pattern" is meant that the printing or coating surrounds circular,

square, rectangular, triangular or other shaped blank dots. This kind of printing or coating is in effect "solid", but leaves uncoated areas which enable the fabric to "breathe" and/or allow the moisture management, which is of general importance, but of particular importance in connection with clothing intended for use eg. by fire fighters and others working in hot environments. The print or coating may, of course, be rendered fire retardant or flame resistant and applied to a heat resistant fabric for such purposes.

Thus, in one implementation of the invention a fabric which is breathable and/or has moisture management properties has adhered thereto, e.g. by a transfer adhesive, one or more arrays of dots each comprising a plurality of aligned, hemispherically coated retroreflective microbeads in such a way that the fabric is exposed for breathing/moisture management at interstices between the dots.

In another implementation of the invention, a breathable and/or moisture management fabric has adhered thereto, e.g. by a transfer adhesive, one or more arrays of dots ("reverse dots") each comprising an area of fabric surrounded by an area of aligned, hemispherically coated retroreflective microbeads adhered to the fabric in such a way that the fabric is exposed for breathing/moisture management in the dot areas.

Typically within a particular array of dots or reverse dots present within a discrete pattern area on the fabric, the minimum area of exposed breathable and/or moisture management fabric within such pattern area is at least about 5%, e.g. at least about 10% and typically at least about 30%, of said pattern area. The maximum area of exposed breathable fabric within such discrete pattern area may be up to at least about 95%, e.g. at least up to about 90% and typically up to about 85% , of said pattern area.

The fabric may have a "daylight" print pattern different to the retroreflective pattern. In particular, the retroreflective pattern may be a solid or substantially solid overall print, with a "daylight" print pattern which is not overall or which is overall, but in different colours in different areas. Colour may be present in the bead areas.

The beads may have a pigment layer, which may comprise photo-luminescent or fluorescent pigment, or they may have a coloured film layer, or they may be embedded in a coloured adhesive layer.

The fabric may be provided with areas of unmetallised beads, which may comprise a colour system such as a pigment or film coating or a coloured embedding adhesive. Unmetallised beads may be backed by a reflective medium to import retroreflectivity.

The fabric may also comprise areas of non-aligned, hemispherically coated microbeads.

The invention also comprises a method for making a retroreflective fabric, comprising the steps of:

- producing a sheet having a layer of microbeads hemispherically metallised on their faces away from the sheet;

- transferring said metallised beads to a fabric, metallised face to the face, in pattern areas.

The fabric is typically one which is breathable and/or has moisture management properties.

The beads may be transferred in a dot pattern or a reverse dot pattern. The sheet, having had the beads transferred in the dot or reverse dot pattern, will have substantial numbers of beads left on it, and may be re-used for a second fabric (and a third, perhaps, and even a fourth, depending upon the numbers of beads removed each time), the pattern being selected to require bead transfer only from areas left beaded after said first fabric transfer. Such re-use of the transfer paper and/or salvaging of the beads can improve the economics of the method of the invention.

The beads may, in any event, be transferred selectively from the sheet to the fabric, even if not in dot or reverse dot pattern.

The fabric may be printed with a pattern of transfer adhesive and the sheet pressed against the fabric so that beads transfer from the sheet to the fabric, or the sheet may be printed with a pattern of transfer adhesive and pressed against the fabric so that beads transfer from the sheet to the fabric.

The transfer adhesive may be one which is activated by heat and the sheet and fabric pressed together with heat to activate the transfer adhesive.

The transfer adhesive may be non-water-based, e.g. a polyamide, plastisol or polyurethane adhesive that may cross-link at elevated temperature.

It has been found that using a transfer adhesive tends to have less of an adverse affect upon the moisture wicking ability of a fabric, compared with some water-based reflective inks, possibly because water-based inks tends to penetrate the fabric to a greater extent.

The sheet may comprise a substrate such as paper, e.g. Kraft paper.

The beads may be attached to the sheet by a linear low density polyethylene adhesive.

A thin primer may be applied over the metallised beads before transfer to the fabric.

When a sheet has been used for transfer printing, metallised beads may be recovered from it for use, eg. in inks. Bead recovery may be effected by bending the travelling sheet over a small radius, such as a small diameter roller or edge. The sheet may be chilled for this, which may embrittle or stiffen the adhesive and allow the beads to pop out as the adhesive gapes over the radius.

Embodiments of retroreflective fabrics and methods and apparatus for making them will now be described with reference to the accompanying drawings, in which:

Figure 1 is a face-on view of one embodiment of a retroreflective fabric of the invention;

Figure 2 is a cross-section through the fabric of Figure 1;

Figure 3 is a view like Figure 1 of another embodiment of fabric;

Figure 4 is a view like Figure 1 of another embodiment of fabric;

Figure 5 is a flow diagram illustrating how fabrics according to the invention (and other fabrics) may be manufactured;

Figure 6 is a diagrammatic illustration of steps in the manufacture of a retroreflective fabric;

Figure 7 is a view of a partially unbeaded sheet after a first bead transfer operation showing an adhesive pattern for a second transfer;

Figure 8 is a diagrammatic section through a fabric having metallised and non-metallised bead areas and areas without beads; and

Figure 9 is a diagrammatic illustration of a bead recovery operation.

The drawings illustrate retroreflective fabrics 11 having a print or coating 12 having discrete retroreflective pattern areas 13 of aligned, hemispherically coated retroreflective glass microbeads.

As mentioned above, tapes, for application to clothing such as jackets and tabards to give night-time conspicuity by virtue of retroreflectivity, have long been made by embedding microbeads in an adhesive coating on a carrier so that they are hemispherically disposed, then metallising the exposed hemispheres of the microbeads, then transferring them *en masse* to an adhesive surface of a tape so that the beads are all aligned with their metallised hemispheres embedded in the adhesive matrix of the tape.

More recently, fabrics have been printed in patterns of retroreflective areas by incorporating hemispherically metallised microbeads in an ink which is used for printing more or less as a normal printing ink. Such fabrics are, however, significantly less retroreflective than the tapes because in the fabric the microbeads are not aligned, which has a deleterious effect on the daylight appearance of the fabric, tending to give a grey cast to it.

The retroreflective fabrics of the present invention, by contrast, can have, in their pattern areas, the kind of retroreflectivity associated with tapes.

Figures 1 and 2 illustrate applying to a breathable and/or moisture management fabric 11 a print of the aligned retroreflective microbeads in a dot pattern, dots 14 of, say, millimetre or sub-millimetre dimensions, corresponding to the dots printed by a silk screen printing process, constituting the pattern areas 13. Since the dots 14 are attached to the fabric 11 by adhesive, which tends not to be breathable, the areas 15 around the dots 14, being free of the adhesive, allow the fabric to breath and/or function for the purposes of moisture management.

It will be understood that each millimetre or sub-millimetre "printing" dot will contain perhaps several hundred light transmissive microbeads, which are typically sized in the range of 20 to 90 microns, e.g. usually about 60 microns.

Figure 3 illustrates a fabric 11 with a reverse dot pattern, in which the bead-free areas 15 appear as dots surrounded by beaded area 14 in the pattern areas 13.

Colour can be present, in the usual way, of course, in the non-beaded areas, but also in the beaded areas. The beads may be applied, for example, to an already printed or coloured fabric 11. For colour in the beaded areas, the beads themselves may be covered in a pigment layer, which may contain a fluorescent or photo-luminescent pigment, especially for daytime conspicuity, or a "day-glow" type of colouration, or have a coloured film layer. The beads may be embedded in a coloured adhesive layer of the fabric.

Figure 4 illustrates a fabric 11 with a retroreflective (this time square) dot pattern and a distinct colour pattern (depicted by areas A, B) which may have been pre-printed before application of the retroreflective dot areas.

Figure 8 illustrates a breathable and/or moisture management fabric 11 having, in addition to metallised beaded areas 14, also areas 16 of non-metallised glass beads which, optionally, are rendered retroreflective by having reflective particles such as metal or mica flake 17 embedded in the adhesive layer 18 attaching the beads to the fabric 11.

The non-metallised beads can, of course, have a colour system which can be any of the systems that can be used for the metallised beads. The fabric 11 may also have areas of non-aligned, hemispherically coated retroreflective microbeads - these can be printed on as retroreflective ink in what is by now the usual way.

The fabric 11 may be a fire-retardant fabric such as a Nomex ® fabric or one treated with a fire retardant such as Proban ®, and the adhesive systems/inks used on the fabric may also be fire-retardant or flame resistant.

Protective clothing made of such materials, especially when made breathable and/or capable of moisture management by discontinuous, eg. dot or reverse dot pattern printing, are especially beneficial since by virtue of the highly retroreflective, aligned microbead areas, they have very good retroreflectivity, and they can by virtue of other colouration be given daytime conspicuity which is not compromised by relatively inefficient areas of non-aligned microbeads which tend to give a grey cast to the fabric in daylight conditions. Of course, as mentioned above, such non-aligned bead areas can be incorporated for special effects, eg. to give contrasting levels of retroreflectivity.

Figure 5 is a flow diagram showing the manufacturing process for fabrics according to the invention, and Figure 6 shows cross sections of the materials involved at various stages.

Step 1 is to apply an adhesive layer 61 to a substrate or carrier such as Kraft paper 62 (see Figure 6A). A suitable adhesive for layer 61 is a linear low density polyethylene (LLDPE). The thickness of the adhesive layer 61 is substantially one half of the bead diameter, the beads 63 themselves being of a substantially uniform diameter - beads referred to as "2F2S" ie. twice fired twice sieved, are especially appropriate.

The beads 63 may be prior-treated in various ways to ensure good metal-to-bead adhesion, for example. Step 2 involves scattering of the beads 63 on to the adhesive layer 61 and levelling them to a uniform, semi-embedded monolayer by a roller R - illustrated only diagrammatically in Figure 6B. If desired, the beads may be applied to the carrier in the manner described in our prior International Application No. WO 00/54079.

In Step 3, the exposed bead surfaces are metallised in the usual way, so that each microbead 63 now has a retroreflective layer of aluminium 64 over half its surface (Figure 6C). The metallisation may be carried out selectively, e.g. according to a predetermined pattern, so that in some areas the beads are metallised and in other areas they are not. In this way, when applied to the fabric, areas of dots consisting of metallised beads and areas of dots consisting of non-metallised beads are obtained. The non-metallised beads may be associated with colourant (e.g. provided on the beads themselves or in the binder adhering the beads to the fabric) and/or reflective material, such as mica or metal (e.g. aluminium) flakes or particles, which may be incorporated in the binder adhering the beads to the fabric. In this way, contrasts in reflectivity and colouration may be achieved.

In Step 4, a thin primer layer 65 is applied to the surface of the beads 63 - see Figure 6D.

At this point, there are alternatives.

At Step 5, adhesive 70 may be applied in a pattern to the primer layer 65, as by screen printing so as to result in pattern areas of dots as referred to above. However, an adhesive may instead be applied overall, and then printed in a pattern, again, eg. of dots as by a screen printing operation, with an ink that "kills" the adhesive. The first of these possibilities will result in transfer of microbeads, subsequently, to the adhesive dots, to result in a dot pattern of microbeads, the second will result in the production of a reverse dot pattern in which the dots are free of microbeads but are surrounded by areas covered in microbeads.

Instead of applying adhesive 70 to the primer-covered bead layer, adhesive may - Step 5' - be applied to a fabric to which the beads are to be transferred. Again, the adhesive may be applied in a dot pattern, or instead, applied overall (at least in areas intended to be retroreflective) and overprinted with a dot pattern of ink, to give a dot pattern or a reverse dot pattern of retroreflective areas respectively.

The adhesive to be applied to the Kraft paper or the fabric to be printed may be a polyamide, plastisol or polyurethane adhesive which may cross-link on application of heat, for improved washability of the fabric.

Bead transfer - Step 6 -is effected under heat and pressure, eg. by bringing the bead-carrying carrier 62 and fabric 11 together between heated rollers to produce the composite illustrated in Figure 6E. The carrier is subsequently stripped from the fabric (Step 7) to leave the microbeads adhered by adhesive 70 to the fabric 11 in the desired dot or reverse dot pattern (see Figure 6F). The process can for instance be run with a 60 inch wide fabric on a reel to reel basis.

Except for any desired after-treatments, the fabric is now finished though other printing, the application of retroreflective ink printing and/or the application of non-metallised bead areas can if desired be effected at this stage.

The Kraft paper, however, may still have copious microbead coverage, and can be re-used, possibly three or more times, depending on how many beads are transferred at each use, to produce another fabric, by displacing the print pattern to utilise the remaining microbeads. Figure 7 shows a partially unbeaded paper with areas 71 from which further beads may be removed in a second transfer operation.

Prior to or after transfer of beads from the transfer paper to the fabric, it is possible to apply coloured adhesive to the transfer paper in areas in which the beads are absent (or removed by transfer), to allow the production of solid areas or patterns of coloured non-reflective adhesive to be transferred to the fabric at the same time as bead transfer is effected.

Even when there are too few microbeads left to make further transfer feasible, the remaining beads can be recovered as illustrated in Figure 9. The paper, beaded side out, is coated to stiffen up the adhesive and run over a small radius such as roller 91, which causes the beads to pop out of their "sockets" in the adhesive for collection and re-use in inks.

It is possible to make a double-sided retroreflective fabric by applying adhesive to both faces of a fabric, or to two transfer sheets, and applying two transfer sheets simultaneously to opposite faces of the fabric. Of course, in the same way, the fabric may be made retroreflective on one face, and otherwise printed on the other face, in each case by transfer printing.

CLAIMS

1. A retroreflective fabric having a print or coating having retroreflective pattern areas of aligned, hemispherically coated retroreflective microbeads.

2. A fabric according to claim 1, in which the print or coating is applied in dot pattern or a reverse dot pattern.

3. A fabric as claimed in claim 1, being breathable and/or capable of moisture management and having adhered thereto an array of printed or coated dots forming a pattern area, each dot comprising a plurality of aligned, hemispherically coated retroreflective microbeads in such a way that the fabric is exposed for breathability and/or moisture management at interstices between the dots.

4. A fabric as claimed in claim 1, being breathable and/or capable of moisture management and having adhered thereto an array of dots each comprising an area of fabric within a pattern area of aligned, hemispherically coated retroreflective microbeads adhered to the fabric in such a way that the fabric is exposed for breathability and/or moisture management in the dot areas.

5. A fabric according to any one of the preceding claims, having a "daylight" print pattern different to the retroreflective pattern.

6. A fabric according to claim 5, in which the "daylight" print pattern is multicoloured.

7. A fabric according to any one of the preceding claims, in which colour is present in the bead areas.

8. A fabric according to any one of the preceding claims, in which the beads are provided with a pigment layer.

9. A fabric according to claim 8, in which the pigment layer comprises photo-luminescent or fluorescent pigment.

10. A fabric according to any one of the preceding claims, in which the beads are provided with a coloured film layer.

11. A fabric according to claim 7, in which the beads are embedded in a coloured adhesive layer.

12. A fabric according to any one of the preceding claims, in which there are areas of unmetallised beads.

13. A fabric according to claim 12, in which the unmetallised beads comprise a colour system such as a pigment or film coating or a colour embedding adhesive.

14. A fabric according to claim 12 or 13, in which unmetallised beads are backed by a reflective medium to impart retroreflectivity.

15. A fabric according to any one of the preceding claims, comprising areas of non-aligned hemispherically coated retroreflective microbeads.

16. A fabric according to any one of the preceding claims, being a fire-retardant fabric.

17. A method for making a retroreflective fabric, comprising the steps of:

- producing a sheet having a layer of microbeads hemispherically metallised on their faces away from the sheet;
- transferring said metallised beads to a fabric, metallised face to the fabric, in pattern areas.

18. A method according to claim 17, in which the beads are transferred in a dot pattern or a reverse dot pattern.

19. A method as claimed in Claim 17 in which the transfer is effected through adhesive applied to the layer of microbeads on the sheet or to the fabric in such a way that the transfer is effective to apply the microbeads to the fabric to produce a patterned area or areas in which parts of the fabric are exposed for breathing and/or moisture management.

20. A method according to claim 18 or 19, in which the sheet, having had the beads transferred to a fabric, is re-used for a second transfer to a second fabric or a different section of the same fabric, the pattern being selected to require bead transfer only from areas left beaded after said first transfer.

21. A method according to any one of claims 17 to 20, in which the beads are transferred selectively from the sheet to the fabric.

22 .A method according to any one of claims 17 to 21, in which the fabric is printed with a pattern of transfer adhesive and the sheet is pressed against the fabric so that beads transfer from the sheet to the fabric.

23. A method according to any one of claims 17 to 21, in which the sheet is printed with a pattern of transfer adhesive and pressed against the fabric so that beads transfer from the sheet to the fabric.

24. A method according to claim 22 or claim 23, in which the transfer adhesive is one which can be activated by heat and the sheet and fabric are pressed together with heat to activate the transfer adhesive.

25. A method according to any one of claims 17 to 24, in which the transfer adhesive is a polyurethane, polyamide or plastisol adhesive.

26. A method according to claim 25, in which the transfer adhesive is a polyurethane or polyamide adhesive that cross-links at elevated temperature.

27. A method according to any one of claims 17 to 26, in which the sheet comprises a paper substrate.

28. A method according to any one of claims 17 to 27, in which the metallised beads are attached to the sheet by a linear low density polyethylene adhesive.

29. A method according to any one of claims 17 to 28, in which a thin primer is applied over the metallised beads before transfer to the fabric.

30. A method according to any one of claims 17 to 29, in which, when a sheet has been used for transfer printing, metallised beads are recovered from it for use eg. in inks.

31. A method according to claim 30, in which bead recovery is effected by bending the travelling sheet over a small radius.

32. A method according to claim 30, in which the sheet is chilled for said small radius bending operation.

33. A method as claimed in any one of claims 17 to 32 in which the beads on the sheet are metallised selectively such that some beads are metallised and others are not.

34. A method as claimed in claim 33 in which, following metallisation, the sheet carries areas of light transmissive beads which are metallised and areas of light transmissive beads which are not and in which both metallised and non-metallised beads are transferred to the fabric.

35. A method as claimed in claim 34 in which the non-metallised beads are associated with colourant and/or light reflective material.

36. A method as claimed in claim 35 in which the colourant and/or light reflective material is incorporated in the adhesive used to adhere the beads to the fabric.

37. A method as claimed in any one of Claims 36 in which a non-water-based transfer adhesive is used for bead transfer to the fabric.

38. A fabric or method as claimed in any one of the preceding claims, the fabric being at least 1 metre, e.g. about 1.5 metre, in width.

39. A transfer sheet for use in transferring retroreflective microbeads to a fabric, comprising at least one area of part-metallised light transmissive beads and at least one area of non-metallised light transmissive beads adhered to the sheet in such a way as to be transferrable to a fabric.

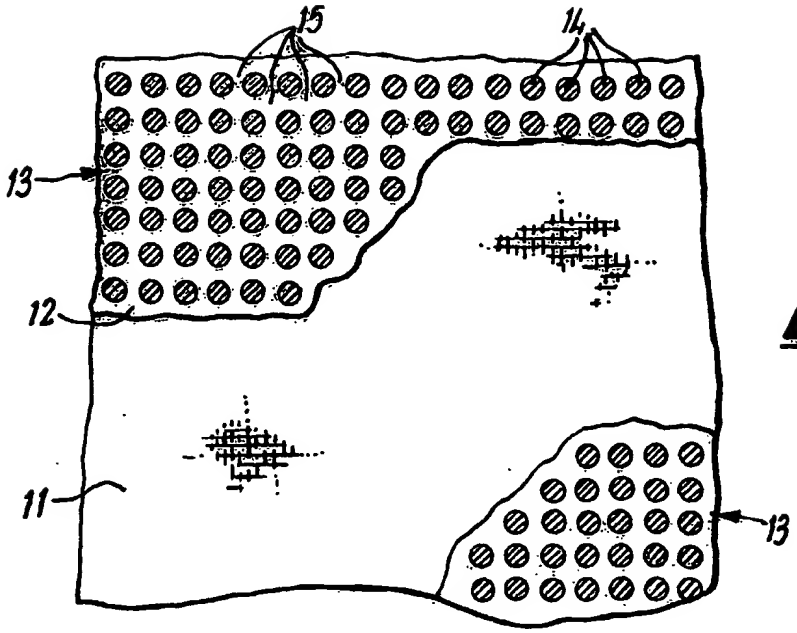

Fig.1

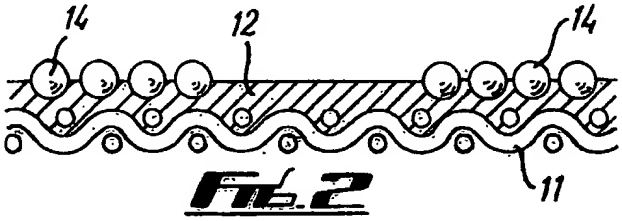

Fig.2

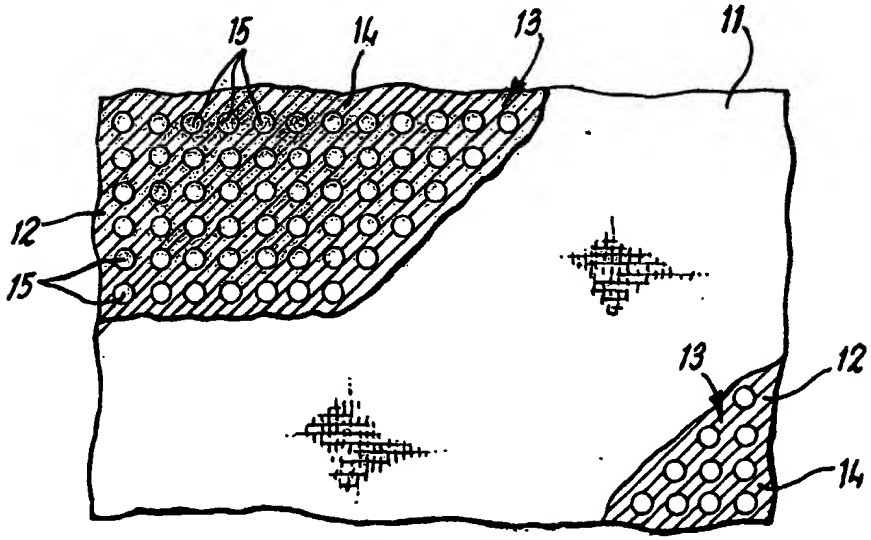

Fig.3

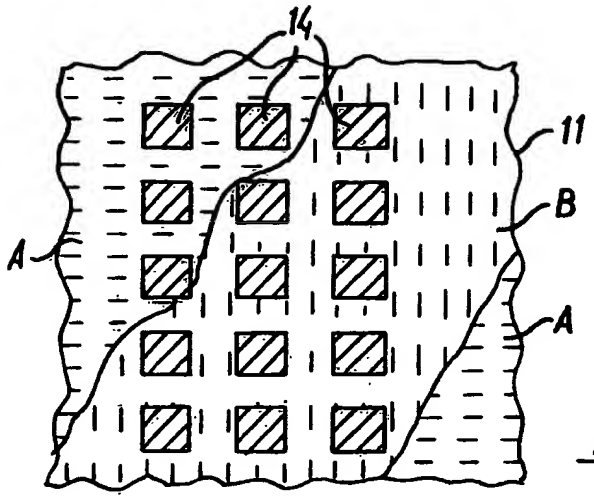

FIG. 4

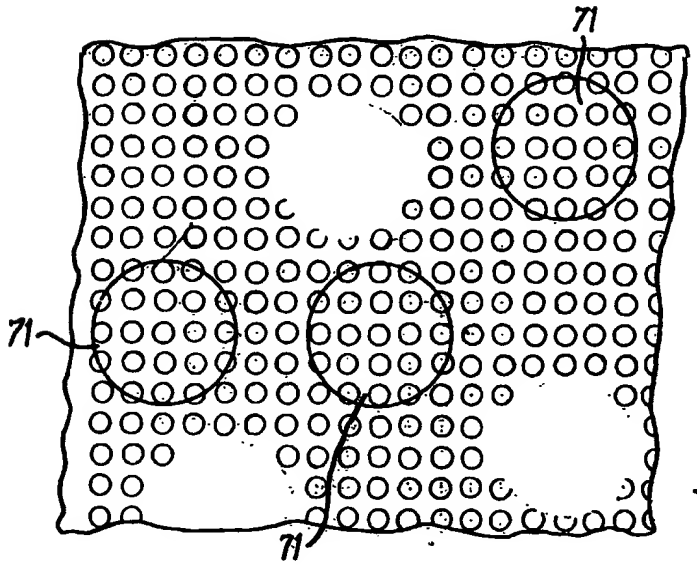

FIG. 7

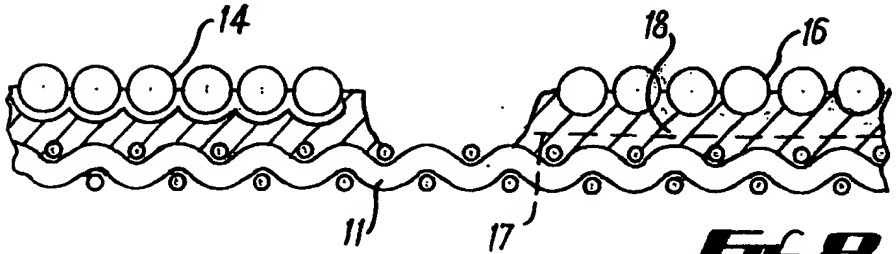

FIG. 8

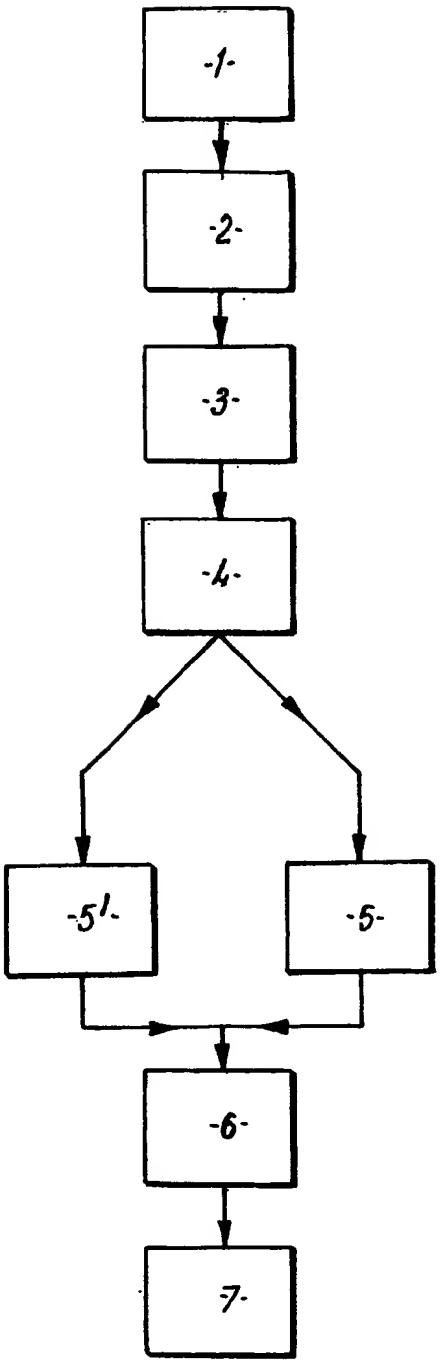

Fig.5

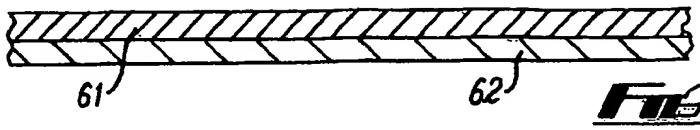

FIG. 6A

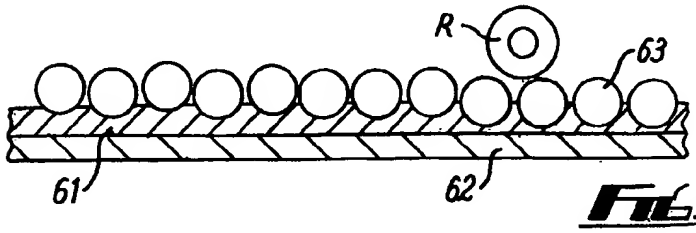

FIG. 6B

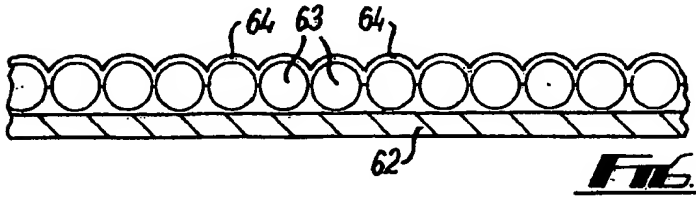

FIG. 6C

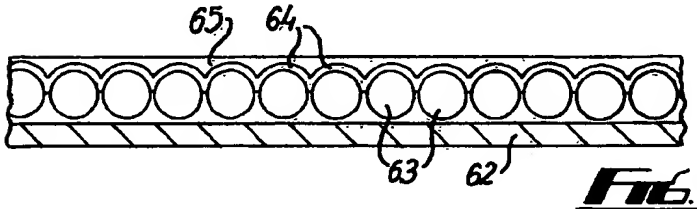

FIG. 6D

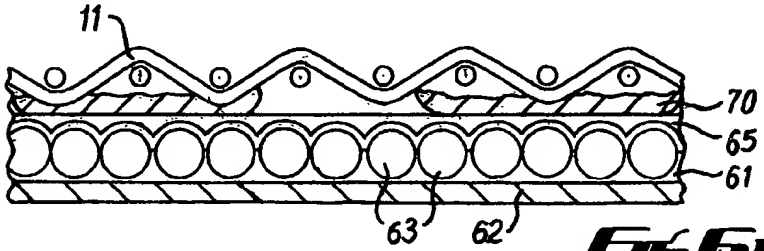

FIG. 6E

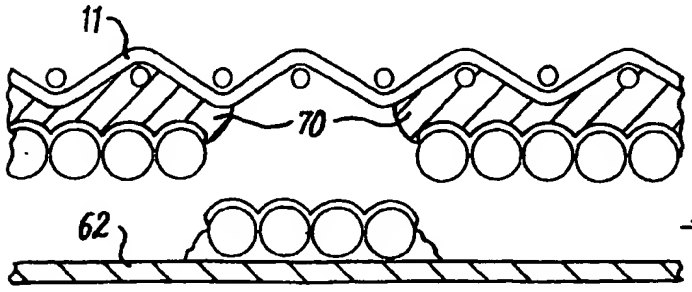

FIG. 6F

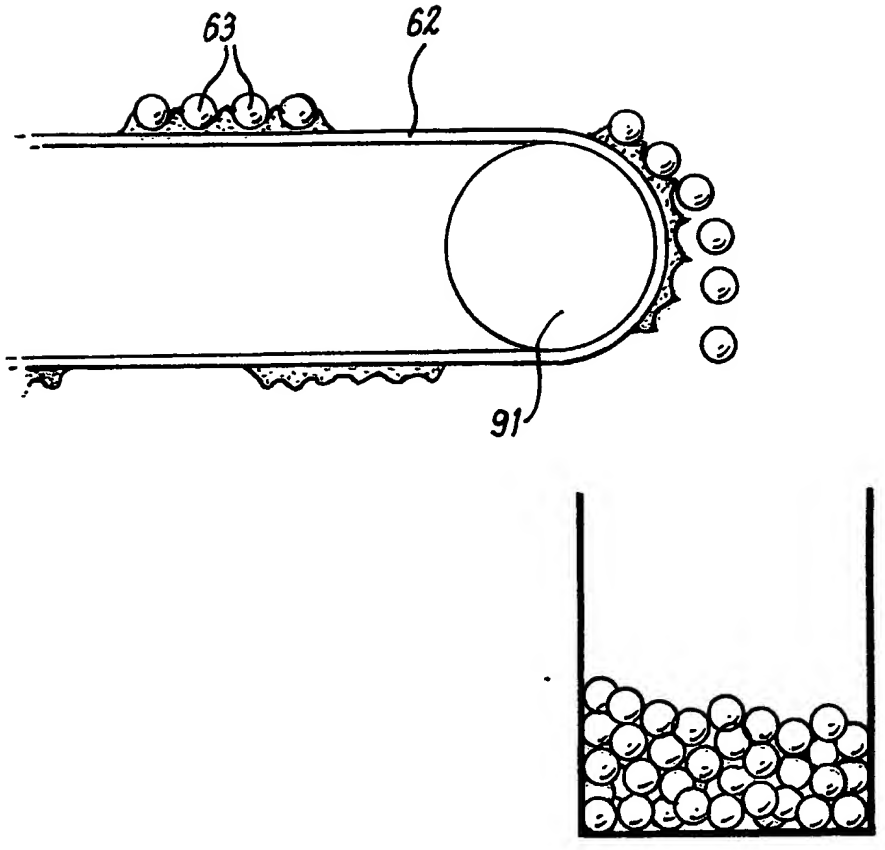

Fig. 9

INTERNATIONAL SEARCH REPORT

Int onal Application No
PCT/GB 20/02777

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D06Q1/12 D06P1/00 G02B5/128

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D06Q D06P G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 94 25666 A (MINNESOTA MINING & MFG) 10 November 1994 (1994-11-10)	1-10, 12-14, 17-19, 21-25, 27-29, 33-35, 37-39
Y	page 2, line 30 -page 5, line 7 page 9, line 6 - line 8 page 10, line 9 - line 14 page 11, line 22 - line 38 page 13, line 5 -page 14, line 15 page 15, line 25 - line 31 examples	36

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 September 2002	17/10/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fiocco, M

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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